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ABSTRACT

The theme of the fifth annual World's Largest Math Event (WLME 5) is "The Power of Nature." This theme encourages students to explore natural forces that affect humankind, including phenomena such as hurricanes, earthquakes, and snowstorms, and the mathematics that underlies their study. The 15 activities for WLMES have been grouped into five major categories that reflect the four elements of nature as named by the ancient Greek philosophers Empedocles and Aristotle: (1) Earth; (2) Wind; (3) Water; and (4) Fire. Teacher notes and solutions follow the activities. Contains 24 references. (ASK)

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THE Power OF Nature

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The fifth annual World's Largest Math Event (WLME 5) is slated for 30 April 1999 with the theme "The Power of Nature." This year's theme encourages students to explore natural forces that affect humankind—including phenomena such as hurricanes, earthquakes, and snowstorms—and the mathematics that underlies their study.

THE Power OF Nature



INTRODUCTION

The goal of WLME 5 is to continue the spirit of celebrating with students and teachers from around the globe the idea that mathematics is a vital part of life itself. WLME 5 will be successful if grades K–16 students around the world participate in this enriching, mathematics-related event. The activities for WLME 5 have been grouped into five major categories, reflecting the four "elements" of nature as defined by the ancient Greek philosophers Empedocles and Aristotle—*Earth, Wind, Water, and Fire*—and a final section called "Bringing It Home." Teacher notes and solutions follow the activities. You can get more students involved and make the event an even greater success by promoting WLME 5 through your local media. See the last page of this booklet to find out how.

Choose one or two activities that will interest your students and explore those activities on 30 April 1999. (Because of scheduling difficulties, we understand that some cannot participate on the day of the event. We encourage such teachers to use these activities whenever it is convenient.)

Embellish them with your own knowledge and information about the theme. Place the poster—the outer page of these materials—in a prominent place in your classroom.

Finally, please extend WLME 5 beyond your classroom. Have students discuss with their families some forces of nature that affect your locality. From a volcanic eruption in the Cascades to a tornado in Texas, a "nor'easter" in New England, or a blizzard in Canada, mathematics plays an inherent role in describing these events. Visit the NCTM Web site at www.nctm.org for additional activities and ideas to support the WLME 5 theme. Or call our Fax on Demand number, (800) 220-8483, and request document #215 (WLME 5) or document #216 (additional activities). Permission is granted to reprint the WLME 5 materials for nonprofit educational purposes.

The NCTM committee members who developed the WLME 5 materials were Daniel Brahier, Connie Laughlin, Jane Martain, Roy Barnes, and Melfried Olson. We are in debt to Mark Saul and Al Cuoco for their careful review of the materials and the many helpful suggestions that they offered.

1 The Powers That Be

The Richter scale was developed by Charles Richter in 1935 as a way of estimating the magnitude, or strength, of an earthquake. A change in one magnitude level represents a tenfold increase in the amplitude, or wave height, recorded on a seismograph (a machine that measures earthquake strength). An earthquake that measures 7 on the Richter scale has 10 times the strength of an earthquake that measures 6. To demonstrate for students the difference between a moderate quake—one measuring 5 on the Richter scale—and a great earthquake—one with a magnitude of 8, such as the 1906 San Francisco earthquake—have students cut a strip of paper one centimeter long. Let this strip represent the magnitude of a moderate earthquake. Then, ask the students how they can represent a magnitude 6, or “strong,” earthquake. Since each change in magnitude represents a tenfold increase in earthquake strength, a 10-cm strip would represent a magnitude 6 earthquake. Next, ask the students to represent the strength of a magnitude 7 earthquake. Finally, take this strip outside to mark off the length of ten of the “7” strips. The length of this line, when compared to the initial 1-cm strip, represents the ratio of the strengths of a “great” and a “moderate” earthquake. Ask the students how they might represent the strength of a magnitude 4 earthquake. What would represent a magnitude 1 earthquake?

Encourage students to investigate earthquakes through the United States Geological Survey’s National Earthquake Information Center Web site at www.geomag.cr.usgs.gov. Have them use their earthquake-magnitude-strips to compare the sizes of famous earthquakes.

2 Construct-a-Cone

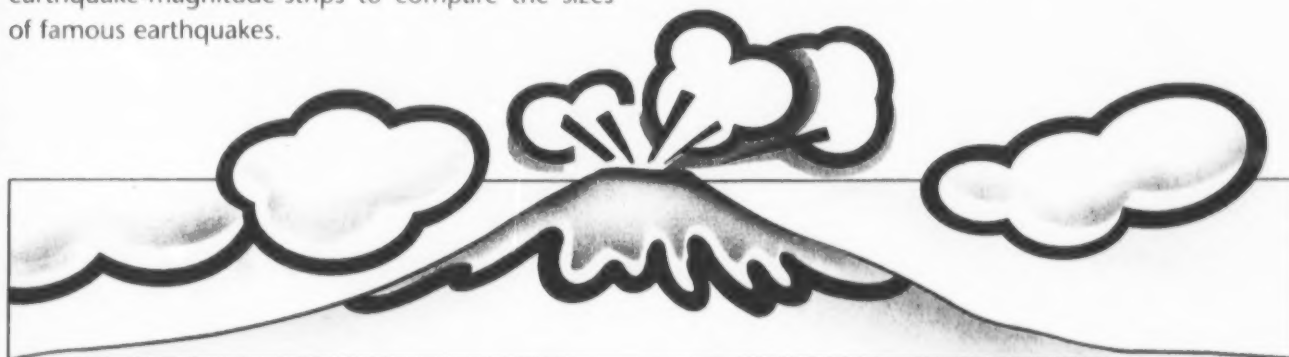
Ask students to draw a “typical” volcano, using their intuition or prior understanding of volcanoes. Then discuss the following facts about volcanoes. Geologists classify volcanoes into three major categories:

— **Cinder cone volcanoes** are made up of lava fragments, and their sides form an angle with the horizontal of about 30° to 40°. Sunset Crater in Arizona is a cinder cone volcano.

— **Composite cone volcanoes** consist of alternating layers of lava and ash and have an angle at the base of about 5° but of about 30° near the summit. Mount Saint Helens in the state of Washington, which erupted on 18 May 1980, is a composite cone volcano.

— **Shield volcanoes** are made primarily from lava flows and slope gently with an angle of about 2° at the base and seldom more than 10° at the summit. The Hawaiian Islands are shield volcanoes.

Distribute three blank sheets of paper and a protractor to the students and ask them to sketch one of each of these three major volcano types, using the given angle-measure parameters. The volcano pictured below is an example of a composite cone. At the beginning of this activity, students were asked to draw a picture of a “typical” volcano. After they have drawn three volcanoes with the information provided here, ask the students which type of volcano their original drawing most closely resembles. Which mental image do most people in the class have when they hear the word *volcano*?



3

Order in the Classroom

When the wind speed in a tropical depression in the Atlantic Ocean reaches 39 miles an hour (63 km/h), it is declared a "tropical storm" and is assigned a name in a pre-determined order for reference. If the winds reach 74 miles an hour (119 km/h), the storm is upgraded to a "hurricane." In 1999, the tropical storms will be named in this order: Arlene, Bret, Cindy, Dennis, Emily, Floyd, Gert, Harvey, Irene, Jose, Katrina, Lenny, Maria, Nate, Ophelia, Philippe, Rita, Stan, Tammy, Vince, and Wilma.

(a) On 21 notecards, write each name above and shuffle the deck. Give one card to each student in the class, and explain that tropical storms and hurricanes are named in alphabetical order. Ask the students to stand in the order in which storms will be named in 1999. When students are in line, tell them to state their names, in order, and ask the class to point out any other patterns they may have noticed in the names. Young students will notice the alternating-gender pattern more easily if girls are given female names and boys are given male names. Note that the letters Q, U, X, Y, and Z are not used to name storms.

(b) Knowing that in 1996 the last tropical storm of the season was named Marco, ask students how many tropical storms or hurricanes there were in 1996.

(c) Ask students to find out how many storms could be named using the names of the students in your class; that is, for how long can you establish an alternating-gender pattern in alphabetical order? Next, have them generate a list of possible names that tropical storms may have had in 1995. Have students check the Web site wxp.eas.purdue.edu/hur_atlantic/atl_names.html to see how their lists match the actual names. (This Web site provides a list of the names of all the Atlantic storms from 1994 through 1999.)

4

A Huge Hurricane

When Hurricane Andrew struck Florida and Louisiana in 1992, it caused about \$20 billion in damage. In the following activities, students will investigate the size of the number "20 billion."

(a) Count out 25 playing cards or index cards and have a student "deal" them onto a table, simulating placing \$1 bills onto a table. Using a stopwatch, students can approximate the time required to deal 25 cards. Ask them to imagine dealing \$1 bills at the same rate as they dealt the cards. How long might it take to deal 1000 \$1 bills? How long would it take to deal 20 billion \$1 bills?

(b) Model the thickness of a pack of 50 \$1 bills by stacking 50 sheets of paper or by measuring a ream of 500 sheets of paper. Using a ruler, measure the height of the paper and use this information to approximate the height of a stack of 20 billion \$1 bills. Have the students calculate where the stack of bills might end if it was laid on its side in a straight line, starting at your school. Is there a well-known city about that far away?

5

Blown Away

(a) Some tornadoes resemble the shape of a truncated cone, whereas others are almost cylindrical. For our purposes, we will model the tornado as a cone. It would not be unusual for a cone-shaped tornado to have a diameter of 500 feet (152 m) at the top and a height of 1000 feet (305 m). Have your students construct a scale model of a tornado using a scale such as 1:150. The model could be an inverted cone where a circle is drawn or marked off with tape on the classroom floor and streamers or lengths of string are taped to the circle and joined at a point on the ceiling. Suppose that the houses in a city could be modeled as rectangular solids that measure 50 feet (15 m) by 30 feet (9 m) and 20 feet (6 m) high. Ask each student to construct a scale model of such a house out of paper, using the same scale, and compare the size of the house to that of the tornado model.

(b) Have students use the formula for the volume of a cone to compare the volume of a typical house to that of the tornado used for the model.

(c) About three-fourths of all the tornadoes in the world occur in the United States. (Only about eighty tornadoes are reported each year in all of Canada, which is far fewer than for Texas, which is much smaller in area!) *The Weather Book* features a statistical account of the frequency of tornadoes in each of the fifty states in the United States. Reprinted below are the average number of tornadoes each year, followed by the average number of deaths resulting from tornadoes each year, for each state. The figures were calculated from data collected between 1959 and 1995. Ask students to devise ways to display this data graphically.

Alabama = 21 (6)	Louisiana = 25 (2)	Ohio = 15 (3)
Alaska = 0 (0)	Maine = 1 (0)	Oklahoma = 53 (4)
Arizona = 3 (0)	Maryland = 3 (0)	Oregon = 1 (0)
Arkansas = 19 (3)	Massachusetts = 3 (2)	Pennsylvania = 10 (1)
California = 5 (0)	Michigan = 16 (5)	Rhode Island = 0 (0)
Colorado = 26 (0)	Minnesota = 19 (1)	South Carolina = 11 (1)
Connecticut = 1 (0)	Mississippi = 24 (8)	South Dakota = 26 (0)
Delaware = 1 (0)	Missouri = 27 (3)	Tennessee = 11 (2)
Florida = 48 (1)	Montana = 5 (0)	Texas = 131 (10)
Georgia = 20 (2)	Nebraska = 38 (1)	Utah = 1 (0)
Hawaii = 0 (0)	Nevada = 1 (0)	Vermont = 0 (0)
Idaho = 2 (0)	New Hampshire = 1 (0)	Virginia = 6 (0)
Illinois = 27 (4)	New Jersey = 2 (0)	Washington = 1 (0)
Indiana = 20 (5)	New Mexico = 9 (0)	West Virginia = 1 (0)
Iowa = 32 (1)	New York = 5 (0)	Wisconsin = 19 (1)
Kansas = 47 (4)	North Carolina = 13 (1)	Wyoming = 10 (0)
Kentucky = 9 (2)	North Dakota = 18 (0)	

One useful presentation of the data would be a double bar graph. Another method would use maps. Give each pair of students a box of crayons or markers and two "clean" maps of the United States that show state boundaries. On the first map, students should devise a color code to use to color the map to indicate the number of tornadoes that are typical for each state (for example, use different and successively darker colors for 0 to 10, 11 to 20, 21 to 30, 31 to 40, 41 to 50, 51 to 60, and more than 60 tornadoes). When they have colored the map, students should discuss which parts of the country appear the most and least likely to have tornadoes.

(d) Students should color the second map to represent the average number of deaths a year (for example, use the same colors as above, respectively, for 0, 1, 2-3, 4-5, 6-7, 8-9, and 10 or more deaths). Students should discuss which parts of the country tend to experience the most deaths attributed to tornadoes. Have students compare the two maps they have colored and determine whether or not the places that have the most tornadoes also tend to have the most deaths caused by the storms.

(e) Have students use an almanac or encyclopedia to find the area of each state and compute which state has the highest ratio of tornadoes for each 10 000 square miles (or km²).



6 Do You Hear What I Hear?

In a summer electrical storm, lightning can often be seen in the sky before the thunderclap is heard. The following are three different ways you may wish to explore this phenomenon with students. Teachers of middle or high school students may prefer to do only part c.

(a) Explain to the students that the sound of thunder travels about 1 mile (1.6 km) every 5 seconds. Use this information to complete the table below:

Miles (km) traveled	1 (1.6)	2 (3.2)
Seconds	0	5

(b) Using the table from part a, have the students write an equation for the function that relates the number of miles or kilometers to the number of seconds and graph the function. They might use D to represent distance and S to represent time. Students can use the graph to further investigate the relationship between distance traveled and elapsed time.

(c) Light travels at about 186 000 miles per second (300 000 km/s). Sound travels at about 760 miles per hour (1200 km/h). Use this information to show why it should take about 5 seconds for the sound of thunder to move 1 mile (1.6 km).

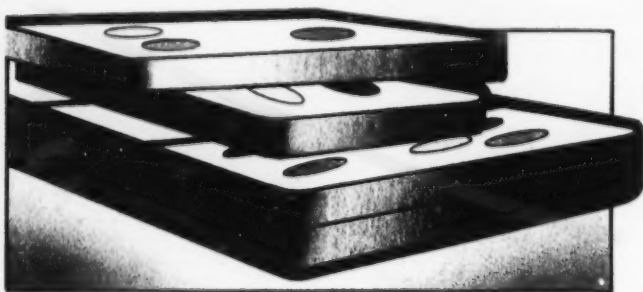


7 Missouri on the Mississippi

The Great Flood of 1993 occurred when both the Mississippi and the Missouri Rivers flooded. The flood lasted three months, and 17 million acres of land were flooded.

(a) According to the Army Corps of Engineers, temporary sandbag levees are often built along rivers in efforts to minimize flood damage. Bags are half-filled with sand, and the first layer of bags is laid parallel to the flow of the river. The second layer crosses the first, perpendicular to the flow of the river. Each layer alternates in direction from that point, and the final height of the levee should be one-third of its width.

Tell students they will use dominoes (or some other type of blocks) to simulate building a levee about 10 inches (or 25 cm) long and two dominoes (laid side by side) wide. Students should first predict how many dominoes it might take to build this structure and then construct it, making sure that the width is about three times the actual height when completed. Have the students determine how many dominoes they will need to build a levee with the same length but a width of three or four dominoes. Discuss any patterns they notice while constructing.



(b) Tell the students that one acre is equivalent to 43 560 square feet (4051 square meters). Have them use a calculator to determine how many acres are in a square mile (or km^2), then find how many square miles (km^2) the Great Flood covered.

(c) Use an almanac to find a country, province, or state that has an area roughly equal to the area that was flooded in 1993.

8 Simulating Centuries

Give students this scenario: "Suppose you are considering two sites for a home along two different rivers. You are told that site A experienced a 100-year flood 5 years ago. Site B last had a 100-year flood 70 years ago. You want to use mathematics to determine the site that is most likely to be flood-free." A 100-year flood is defined as the high-water level that one might expect, on average, once every century from some body of water. A common misconception is that a 100-year flood happens "every 100 years," which is no more true than assuming that you will roll a 1 every sixth time you roll a die.

(a) Start investigating this idea by simulating 10-year floods. Have the students use a bag of ten tiles, one of which is a different color from the others, to model a decade of stream levels by drawing a tile from the bag, noting the result, and returning the tile to the bag. Each time the different-colored tile is drawn represents a 10-year flood. (Students might also use a spinner numbered 1 to 10, or a deck of cards using only the ace through the 10 of one suit.) Have the students do ten trials, recording their results. Once the data are collected, have a class discussion and determine how many students had exactly one 10-year flood in 10 "years," how many had zero, and how many had more than one.

(b) Extend the investigation to a 100-year flood. Use a table of random numbers, a graphing calculator or computer with a random number generator, or place the numbers 1 to 100 on identical cards and draw them one at a time to produce integers from 1 to 100. Have each student simulate a century of floods by drawing or generating a random number 100 times. A "100" produced by the random number generator represents a 100-year flood. Once the data are collected, have a class discussion and determine how many students had exactly one 100-year flood in 100 "years," how many had zero, and how many had more than one.

(c) Ask the students to explain which site mentioned in the opening scenario is most likely to be flood-free for the foreseeable future. Have them explain their thoughts using the mathematics explored in this activity.



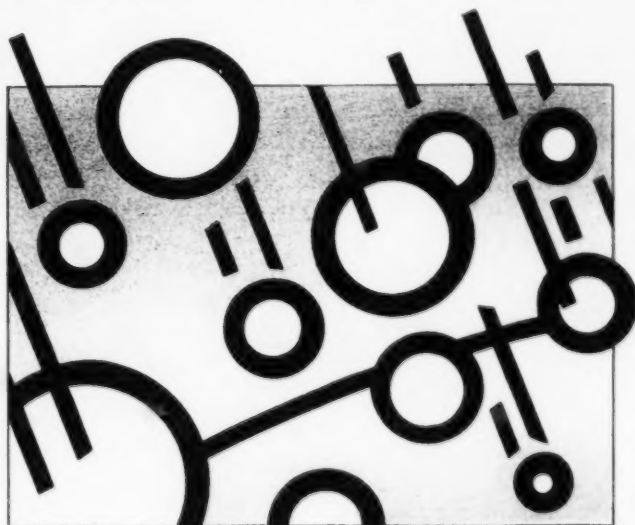
9 Hail to the Chief

On average, a hailstone measures $\frac{1}{4}$ inch (6 mm) in diameter. When a thunderstorm is labeled "severe," it often produces winds in excess of 55 miles per hour (89 km/h) and hail measuring $\frac{3}{4}$ inch (19 mm) in diameter.

(a) Using clay or Play-Doh™, students can make models of small hailstones and a large hailstone. Have the students determine how many of the $\frac{1}{4}$ -inch (6-mm) stones it takes to form a hailstone $\frac{3}{4}$ inch (19 mm) in diameter by using a balance, by combining small stones into a large stone, or by making smaller stones out of a large stone.

(b) At the upper grade levels, display a model of each size of hailstone and ask students to predict how many $\frac{1}{4}$ -inch (6-mm) stones can be made from one $\frac{3}{4}$ -inch (19-mm) stone. Then have students use the formula for the volume of a sphere to verify the number algebraically.

(c) The largest hailstone ever found in the United States measured 5.57 inches (14.1 cm) in diameter and weighed 1.67 pounds (0.75 kg). The largest hailstone ever recorded fell in India in 1939 and weighed 7.5 pounds (3.4 kg). Have students estimate the size of the Indian hailstone and determine how many $\frac{1}{4}$ -inch (6-mm) hailstones could be made from it. Tell the students to assume that the volume of a hailstone is directly proportional to its weight.



10 Where's the Water?

In the water cycle, the earth's water goes from oceans, rivers, and streams to the atmosphere and then falls to the earth again as precipitation. This activity will help students visualize where all the earth's water is at any given time, and it will help students visualize percents.

Give each student a piece of 10×10 square grid paper to represent all the water in the cycle, on, above, or below the earth. Ask the student to use different colors of crayons or markers to color the large square to show the following proportions. Students should represent a tenth of a percent by slicing a square into ten slices.

- 97 percent of the water is salt water located in the oceans (green).
- 2.3 percent is in solid form in the polar ice caps (blue).
- 0.4 percent is underground water (yellow).
- 0.2 percent is in lakes and rivers (red).
- 0.1 percent is in the soil and the air (black).

Discuss the amount of fresh water compared to salt water and the implications of this distribution of water in regard to raising crops and feeding people.



11

Becoming Comfort-Able

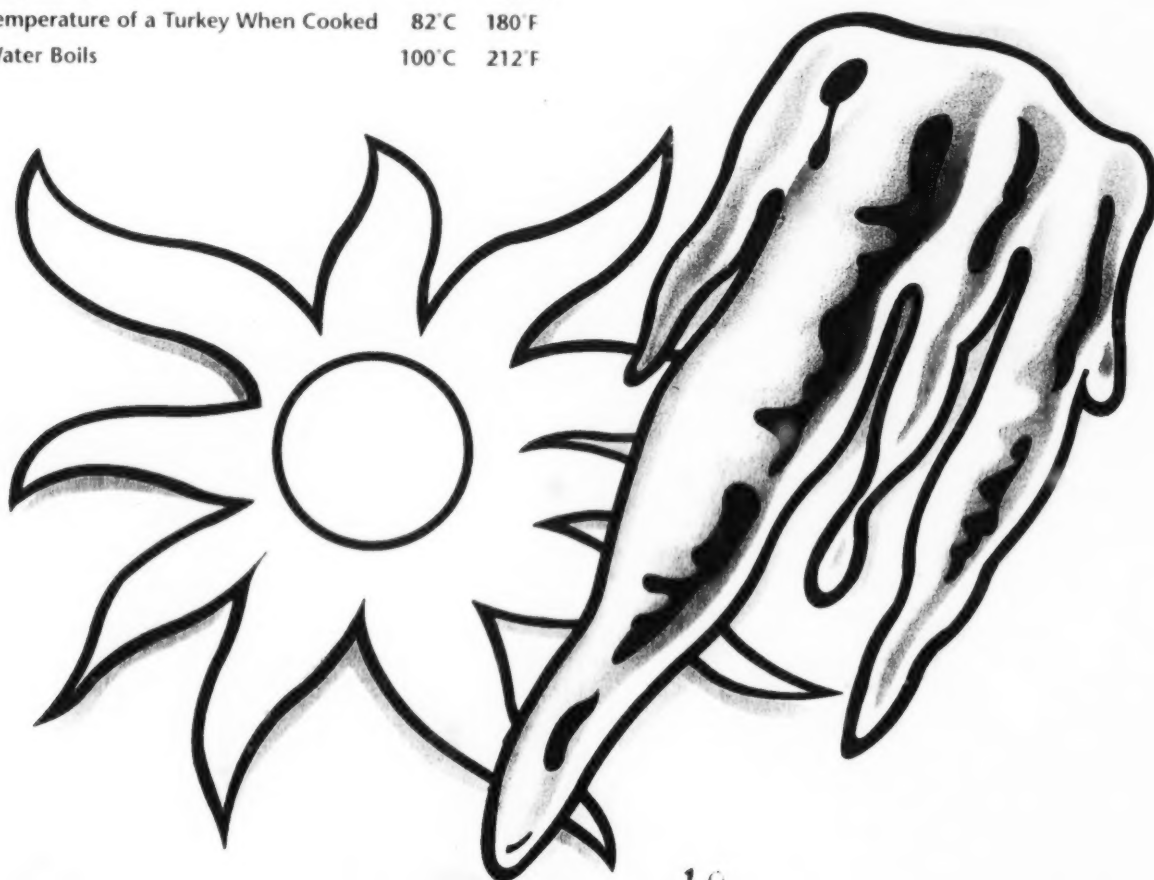
In the United States, temperatures are almost always reported in degrees Fahrenheit. In Canada and Mexico as well as most other places in the world, temperatures are generally reported in degrees Celsius. On the Celsius scale, water freezes at 0° and boils at 100° , but on the Fahrenheit scale, water freezes at 32° and boils at 212° .

(a) Create eighteen cards that students can hold—each containing one of the pieces of information in the following table.

Physical Indicator	Degrees Celsius	Degrees Fahrenheit
Water Freezes	0°C	32°F
Comfortable Room Temperature	22°C	72°F
Temperature on a Warm Summer Day	29°C	85°F
Body Temperature	37°C	98.6°F
Temperature of a Turkey When Cooked	82°C	180°F
Water Boils	100°C	212°F

Shuffle the cards, then give each student a card with one piece of information, such as "Water Freezes." Students then find the two people who "match up" with them. For example, the three students with the "Comfortable Room Temperature," " 22°C ," and " 72°F " signs should form a group of three. Younger children might use only twelve cards and match two, rather than three, for a group (e.g., "Water Boils" matches with " 212°F "). Alternatively, make a puzzle of the information in the chart and ask students to put the information back into order. Most students will need to reason on the basis of prior knowledge to help them match up the groups.

(b) Have students create a line graph of the temperatures from the table, using Celsius temperatures on one axis and Fahrenheit on the other. Ask them to use their graph to discover the formula for converting from one temperature scale to the other.



12 The Heat Is On

The heat index is a measure of how warm or cool it feels when the skin is exposed to a particular temperature and percentage of humidity.

For example, in the table below, if it is 85°F with a 70 percent humidity level in the air (high moisture), the temperature will feel more like 93°F to the skin.

(a) In the table, any value less than 80°F (27°C) is considered comfortable, whereas values greater than 90°F (32°C) are "extreme"; temperatures more than 100°F (38°C) are "hazardous"; and heat indexes more than 110°F (43°C) are considered "dangerous."

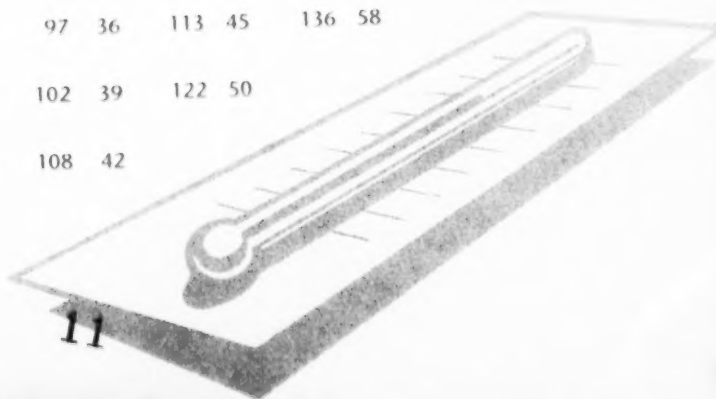
Have students approximate the heat index for a day on which it is 81°F with 80 percent humidity and other combinations of your choice.

(b) Have students suppose that it is 95°F in Las Vegas with a 10 percent humidity level. Then have them estimate the temperature on a very humid day in Toronto (90 percent humidity) that would feel about the same as Las Vegas on that day.

(c) Have students investigate whether your school or district has policies that prevent athletic practices or other strenuous activities on days when the heat index exceeds a certain level.

HEAT INDEX

	°F 70	°C 21	°F 75	°C 24	°F 80	°C 27	°F 85	°C 29	°F 90	°C 32	°F 95	°C 35	°F 100	°C 38	°F 105	°C 41
0%	64	18	69	21	73	23	78	26	83	28	87	31	91	33	95	35
10%	65	18	70	21	75	24	80	27	85	29	90	32	95	35	100	38
20%	66	19	72	22	77	25	82	28	87	31	93	34	99	37	105	41
30%	67	19	73	23	78	26	84	29	90	32	96	36	104	40	113	45
40%	68	20	74	23	79	26	86	30	93	34	101	38	110	43	123	51
50%	69	21	75	24	81	27	88	31	96	36	107	42	120	49	135	57
60%	70	21	76	24	82	28	90	32	100	38	114	46	132	56	149	65
70%	70	21	77	25	85	29	93	34	106	41	124	51	144	62		
80%	71	22	78	26	86	30	97	36	113	45	136	58				
90%	71	22	79	26	88	31	102	39	122	50						
100%	72	22	80	27	91	33	108	42								



13

Chill Out!

The *windchill index*, or “chill factor,” is a measure of the heat loss from the body when temperature and wind speed are combined. It feels colder outside when the wind is blowing than when the air is still. Whenever the windchill drops below -10°F (-23.3°C), it is considered “bitterly cold”; and when the windchill values drop below -20°F (-28.9°C), it becomes dangerous because human flesh can freeze within one minute. Have the students visit the following Web site to view a “Wind Chill Chart” (or print one out and duplicate it for the class): covis.atmos.uiuc.edu/covis/visualizer/help/obs/wchill1.html.

(a) Have the students find a variety of combinations of wind speed and air temperature that would be equivalent. For example, if the air temperature is -20°C , but winds are only 10 km/h, the temperature feels the same as if the air temperature was -4°C but the winds were blowing much harder—about 50 km/h.

(b) Some areas in the United States and Canada regularly experience extremely low windchills. Have students investigate whether your school or district has policies regarding school closure, outdoor recess, or extracurricular activities based on the windchill index.

(c) At the Web site www.cvfn.org/weather/windchill.html, a formula for calculating windchill is presented as

$$WC = 91.4 - (0.474677 - 0.020425V + 0.303107 \sqrt{V})(91.4 - T)$$

where WC is the windchill index in degrees Fahrenheit, V is the wind speed in miles per hour, and T is the air temperature in degrees Fahrenheit. Have students choose a temperature to remain constant and graph this function on a graphing calculator. Ask the students to use the Trace feature to determine windchills from wind speed. (Note that students will have to select a single temperature to draw a graph, since the function has two variables.) Wind speeds above 40 miles per hour have little effect on the windchill index. Ask students to describe how the graph shows this phenomenon.



WIND CHILL TABLE

	Air Temperature ($^{\circ}\text{C}$)												
	8	4	0	-4	-8	-12	-16	-20	-24	-28	-32	-36	-40
0	8	4	0	-4	-8	-12	-16	-20	-24	-28	-32	-36	-40
10	5	0	-4	-8	-13	-17	-22	-26	-31	-35	-40	-44	-49
20	0	-5	-10	-15	-21	-26	-31	-36	-42	-47	-52	-57	-63
30	-3	-8	-14	-20	-25	-31	-37	-43	-48	-54	-60	-65	-71
40	-5	-11	-17	-23	-29	-35	-41	-47	-53	-59	-65	-71	-77
50	-6	-12	-18	-25	-31	-37	-43	-49	-56	-62	-68	-74	-80
60	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-70	-77	-83

Wind speeds above 60 km/h (40 mi/h) have little additional chilling affect.

14

Trivio-Logic

From among the many notable natural events that take place around the world, we present eight phenomena that occurred in different locations around Canada and the United States. Here are the facts about each event:

1. Most damaging hailstorm in Canada's history (\$100 million of damage in fifteen minutes)
2. Highest surface wind speed on record (231 mph [372 km/h])
3. Largest recorded earthquake to strike Canada or the forty-eight contiguous states of the United States (8.1 on the Richter scale)
4. Highest average yearly snowfall in the forty-eight contiguous states of the United States (683 inches [734 cm] per year)
5. Most rainfall in the shortest time (12 inches [30.5 cm] of rain in forty-two minutes) in the United States
6. Most snow to fall in a twenty-four-hour day (76 inches [193 cm])
7. Lowest recorded temperature in U.S. history (-79.8°F [-62.1°C] on 23 January 1971)
8. Site of Canada's worst blizzard (1947)

These eight events occurred at one of the following locations: (a) Regina, Saskatchewan; (b) Queen Charlotte Island, British Columbia; (c) Holt, Missouri; (d) Silver Lake, Colorado; (e) Mount Washington, New Hampshire; (f) Paradise Ranger Station, Washington; (g) Prospect Creek, Alaska; and (h) Calgary, Alberta. Using the following list of clues, determine which event occurred at which location. Good luck!

— The strongest earthquake in Canadian history took place west of Canada's worst blizzard.

— Snow falls heaviest in the Cascade Mountains, but the most snow in twenty-four hours fell in the Rockies.

— The state with the lowest recorded temperature starts with the same letter as the province with the costliest hailstorm.

— The names of the state with the most snow in twenty-four hours and the state where the heaviest rainfall took place have the same number of letters.

— One of the following is located in New England: the place with the most snow in twenty-four hours, the place with the highest recorded surface wind speed, the place with the heaviest rainfall.

15

Your Hometown

Each city, county, state, province, or country experiences its own unique effects from natural forces at work.

In the United States, people living in Florida, the Southeast, and up the East Coast deal with hurricanes but rarely worry about earthquakes. People living in southern California deal with earthquakes quite often but rarely see any snow. People who live in the northern states and in Canada often deal with large amounts of snow, but only those people in mountainous regions experience danger from avalanches. People residing in the state of Washington have witnessed one of the most powerful volcanic disasters within the last 20 years.

Divide your students into teams of three or four and have each team select a common natural force that affects your region—from temperature extremes to tornadoes, avalanches, wildfires, El Niño effects, and so forth. Each team should research the effects that its particular natural force has had on your region and generate a short set of mathematical problems relating to that force. Teams can make presentations to the class and duplicate mathematical problems for others to solve.

TEACHER NOTES

1. The magnitude 5 strip measures 1 cm; the magnitude 6 strip measures 10 cm; the magnitude 7 strip measures 1 m, and the magnitude 8 strip measures 10 m. A magnitude 4 strip measures 1 mm, and a magnitude 1 strip measures 0.001 mm! Note that earthquakes with magnitude less than 2.5 are typically not felt but can be recorded by seismographs.

This activity may be done using a 1-inch strip for the magnitude 5 earthquake, but the magnitude 8 strip will then be 83 feet 4 inches long! Base-ten blocks or Unifix cubes can be used to model the magnitude 5 and 6 earthquakes. In order to represent magnitude 7 and 8 earthquakes, you may need to use paper strips, since 100 ten-strips are needed to model a magnitude 8 earthquake.

2. Students' pictures are likely to vary in height by a great deal, but following the angle measures given in the problem results in figures that look much the same. Thus, students can all draw accurate sketches without being concerned about height. They may find it easiest to measure the angles on the "left side" and the "right side" of the volcano drawing and sketch the picture so that the sides meet in the middle. Students can also construct three-dimensional models of each type of volcano using clay and following the angle measure restrictions. This will help them to visualize the physical differences among the types of volcanos while using angle measure to create the models.

WIND

3. (a) Children should recognize that the names alternate between female and male (e.g., Arlene is female, but Bret is male; Cindy is female, and Dennis is male, etc.). Knowing that the names are alphabetical and alternate in gender, the students can create their own list of hurricane names. Each year, the first storm's name alternates by gender. For example, 1996 began with Arthur, 1997 was Ana, 1998 was Alex, and 1999 will be Arlene. Students may be interested to know that naming tropical storms began in 1953, and from 1953 until 1979, storms were given only female names. Since 1980, the World Meteorological Organization has made it a practice to alternate storm names between male and female.

(b) 13. M is the thirteenth letter in the alphabet.

Students might want to read about hurricanes as an extension to this activity. Children in grades K-3 might enjoy *Wild Weather: Hurricanes!* by Lorraine J. Hopping (1995), and older children can read *Hurricanes* by D. M. Souza (1996).

4. (a) It takes approximately 10 seconds to deal 25 cards onto a table, which means it takes about 0.4 seconds to deal each card. At this rate, it would take 400 seconds, or 6 minutes and 40 seconds, to deal 1000 \$1 bills. Using a proportion, you can calculate that it would take 8 billion seconds to deal 20 billion \$1 bills. Converting this time to years, we find that it would take more than 250 years of constant dealing to deal out 20 billion \$1 bills!

(b) The answers may vary, depending on the type of paper used to model the problem. A ream of 500 sheets of paper is approximately 2 1/16 inches (5.24 cm) high. So 20 billion sheets of paper would be more than 82 million inches, or about 1300 miles (2096 km), high! The U.S. Department of Treasury states that the thickness of 50 \$1 bills

would be 0.215 inches (0.55 cm). Using this figure, we find that the height would be 1357 miles (2184 km).

5. (b) The volume of the tornado model can be calculated using the formula $V = 1/3 \pi r^2 h$.

This makes the volume about 65.5 million cubic feet. The volume of the tornado is well over 2000 times that of the 50' x 30' x 20' house.

(c), (d) Students may be surprised to see the contrast between, say, Texas, which averages 131 tornadoes a year, and Indiana, which averages only 20 tornadoes a year. The tornadoes that generally form in Indiana tend to be much more intense and deadly, so that even though Texas has six times as many tornadoes in a year as Indiana, it has only twice as many deaths on the average. About 75 percent of all the tornadoes in the world take place in the United States, and most of these occur in "Tornado Alley"—to find out why, go to www.windows.umich.edu, find the tornado link, and follow it to the link to Tornado Alley. Most tornadoes in Canada occur in a band stretching from southeastern Manitoba to the northwest, although some occur in southern Quebec and as far east as New Brunswick.

6. (b) Students should come up with the equation $S = 5D$ or $D = 1/5 S$. In each instance, the function is linear. Realistically, thunder can be heard only to a distance of about 20 miles (32 km).

(c) Dividing 760 miles per hour by 60 gives miles per minute. Dividing by 60 again results in miles per second, which is 0.21. If the sound can travel about 0.21 miles per second, then it would travel 1 mile in about 5 seconds. Light travels so fast that you see the lightning virtually instantaneously.

WATER

7. (a) The number of dominoes required for a model levee will vary, since the size of dominoes varies. In one example, the length of a domino is about 1 5/8 inches (4.1 cm), so a model of a levee two dominoes wide would require a height of just over 1 inch (2.7 cm). To make a 10-inch model requires two rows of 12 dominoes, laid side by side, stacked four layers high. Therefore, it takes 96 dominoes to build this structure ($2 \times 12 \times 4$). Increasing the width to three dominoes theoretically raises the number needed to 144 (1.5×96), but this cannot be effectively modeled, because its odd-number width makes it impossible to alternate directions.

(b) Since 1 acre is 43 560 square feet and a square mile is 27 878 400 square feet, there are $27\,878\,400 \div 43\,560 = 640$ acres in a square mile. Dividing 17 million by 640 shows that the Great Flood of 1993 covered nearly 27 000 square miles. A square kilometer is 1 000 000 square meters, and 4051 square meters are in one acre, so 247 square kilometers are in one acre. From this information we can calculate that the Great Flood of 1993 covered about 69 000 square kilometers.

(c) In an almanac, the area of the state of West Virginia is listed as 24 231 square miles (62 809 km²). The area of the province of New Brunswick is listed as 27 834 square miles (72 149 km²).

8. (a), (b) By doing this activity, students will realize that it is possible to have several 100-year floods or none at all within a century. Essentially, all that a 100-year flood means is that there is a 1 in 100 chance, in any given year, that such a flood will happen in that year.



(c) Neither site is better. Some might argue that the site with the more recent flood will have 95 flood-free years, whereas others will argue that the drier site has proved itself flood-free and is likely to stay that way. The fact is that both sites have a 1 percent chance of flooding in any given year. That is, the probability for a flood is the same for both sites.

9. (a) Using the Play-Doh™ or clay, students can place the 3/4-inch (19-mm) ball on one side of a balance and place the smaller 1/4-inch (6-mm) balls on the other side until the scale balances. It should take about 27 smaller balls to balance the scale. They can then take the 27 smaller balls and mold them together to compare the size with the original larger ball.

(b) If students use the formula for the volume of a sphere, $V = 4/3 \pi r^3$, they can determine the number of small hailstones as follows:

$$\frac{\frac{4}{3} \pi \left(\frac{3}{8}\right)^3}{\frac{4}{3} \pi \left(\frac{1}{8}\right)^3} = \frac{\left(\frac{3}{8}\right)^3}{\left(\frac{1}{8}\right)^3} = \left(\frac{3}{1}\right)^3 = 27.$$

This result runs counter to our intuition that might suggest "three times the diameter" means "three times more volume." Students can strengthen their understanding of this idea by considering the volume of a cube. A cube with side s has volume s^3 . Tripling the side gives a side length of $3s$ and a volume of $(3s)^3 = 27s^3$.

(c) Knowing the weight and diameter of the U.S. hailstone, density—the weight per cubic inch (or cm^3)—can be calculated. It is important to remember that a comparison of volumes and not just diameters is required. Using density and the total weight of the Indian hailstone, one can solve for radius and double the value to find an approximate diameter of 9.2 inches (23.4 cm). Nearly 50 000 "normal sized" hailstones could be made from this one large stone!



10. The large square should be colored so that 97 squares are green; 2 3/10 squares are blue; 4/10 of a square is yellow; 2/10 of a square is red; and 1/10 of a square is black. When students see that 97 out of 100 squares are green but barely two-tenths of one square is red, they can come to appreciate the relative scarcity of drinking water on the earth. This can lead to a discussion of the importance of water conservation.

HEAT AND COLD

11. (a) Few students feel comfortable with both systems of measuring temperature. This activity will help students familiarize themselves with the two systems. You might want to add some other temperatures to the list to fit your needs.

(b) Graphing the Celsius temperatures versus the Fahrenheit temperatures produces a straight line. Students can then find the equation of the line, which gives a conversion formula. Basing calculations on the freezing and boiling points of water yields the familiar formulas $C = (5/9)(F - 32)$ and $F = (9/5)C + 32$.

12. (a) Students may want to discuss the heat index in their own location. They can discuss a typical temperature and humidity level for their location and compare it to other cities. A Heat Index Calculator is available on the Internet, which allows a person to enter the temperature in

Fahrenheit or Celsius and the humidity level to generate the heat index. It can be found at nwselp.epcc.edu/elp/heatindex.html.

(b) If the humidity level is 90 percent in Toronto, then an air temperature of about 82°F (28°C) would feel about the same as a 95°F (35°C) day in Las Vegas. This difference prompts people on a miserably hot day to sometimes remark, "It's not the heat; it's the humidity."

13. (a) Answers will vary.

(b) The formula for windchill involves a square root function, resulting in such a gentle slope that x -values (wind speeds) of more than 40 miles per hour (64 km/h) simply don't change the y -values significantly. Beyond the 40 mph mark, the graph is almost horizontal and will, in fact, begin to show an increase in temperature when winds exceed 57 mph or so when the air temperature is 20°F (−6.7°C). This is a reminder that the formula is merely a mathematical model and has its limitations.

BRINGING IT HOME

14. Canada's most costly hailstorm occurred in Calgary, Alta.; the highest surface wind speed was on Mount Washington, N.H.; Canada's strongest recorded earthquake struck on Queen Charlotte Island, B.C.; the highest average snowfall is at the Paradise Ranger Station, Wash.; the heaviest rainfall was in Holt, Mo.; the most snow in 24 hours fell in Silver Lake, Colo.; the lowest recorded temperature was at Prospect Creek, Alaska; and Canada's worst blizzard struck in Regina, Sask.

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Promoting WLME 5

Promoting the value of mathematics to students is the responsibility of every teacher. On Friday, 30 April 1999, we ask that you broaden your role to include promoting mathematics to the local community through the media.

The following steps will help you obtain media coverage for the event—coverage that will show the positive activities taking place in your classroom and in your school.

First, make a list of all the local media you want to reach, including newspapers and radio and television stations.

Second, identify the reporters who cover education issues for the newspaper or radio and television stations you want to reach.

Next, write a short (one page) media alert for your local press. Be sure to include who, what, when, where, why, and how. (Note: a media alert is much easier to write than a press release, since it is composed of short tidbits of information. See the sample media alert for guidance in composing your own.)

Type your media alert on your school's letterhead. Be sure to include a contact name and phone number. This will enable interested reporters to contact you easily. Mail the media alert approximately one week before the event to give reporters time to check their schedules and gather any additional information they may need to cover the story.

Finally, if you do anticipate coverage by your local media, get parental permission for children to be photographed and interviewed prior to the event. This precaution will save reporters time and earn you their gratitude.

